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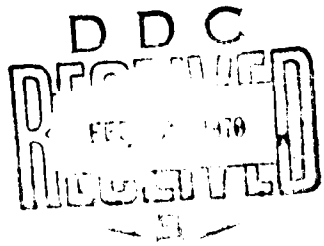

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ALTERNATIVE TECHNOLOGIES FOR INFORMATION NETWORKS*

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This Paper concerns some of the economic considerations inherent in designing user services that incorporate various communication systems. It will describe three such services that Rand considers important in providing information to the biomedical community comprised of practicing physicians and those engaged in teaching and research, as well as other professionals directly involved in biomedical research and in the practice of medicine. Following this discussion will be a brief description of some technological developments that might make these or similar services available in less expensive ways, as well as some problem areas.

The primary point is that communications modalities that offer considerable service at relatively reasonable cost are currently available. The use of these services, however, must be considered at length prior to implementation. Such consideration must take place only after a detailed appreciation of the nature of the information to be transferred, and the user community to be served. The message must define the medium.

The use of broadband networking can, in some circumstances, be an extremely effective means of transmitting

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information. Rand has investigated the cost and potential coverage of land-circuit television networks. One particular application is the networking of ETV stations. In such networks, a major component cost is the utilizing of AT&T interchange channels to connect points in the network. This cost is based largely on the airline distance between these points. Therefore, one of the preliminary tasks is the determination of minimum distance network configurations. Figure 1 is a representation of such a network for all the ETV stations serving at least one Standard Metropolitan Statistical Area (SMSA). This network reaches 106 SMSAs and requires about 12,000 miles of interconnection channel. A single hour of networking can be purchased for about $78,000. The network puts about 82 percent of the physician population within broadcast reach.

Based on estimates of 1970 physicians' population, this translates into a networking cost of about twenty-five cents per potential viewer hour. Interestingly, a nationwide network of only five major cities, because of the concentration of physicians in these cities, can reach about 30 percent of the physician population, and also has a low cost per potential physician viewer hour. Figure 2 depicts the costs for such operation.

Ignoring the problem of privacy protection assume that this same network was used to broadcast information in a patient-specific case in order to obtain expert consultation. Now the cost (considered as the cost for an hour of consultation) is relatively high, and the use of broadband communication links is much less desirable.

As an alternative, consider the use of telephone access to a library of recorded messages. In this case, the physicians might have as many as 1000 different titles from which to choose. Thus, there might be several messages providing expert information on various patient-specified problems. Using Inward Wide Area Telephone Service (INWATS) to

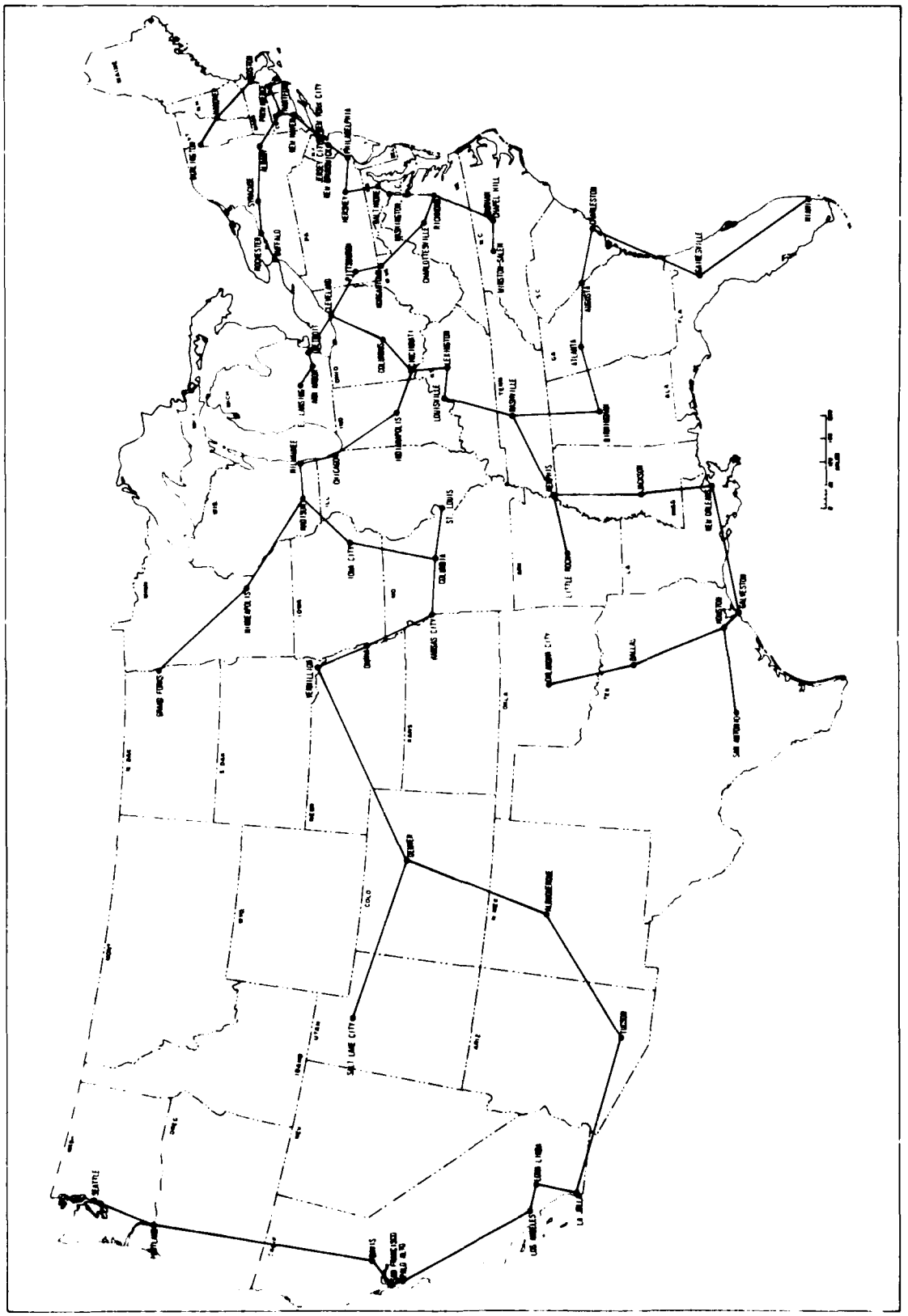

Fig. 1--Minimum Distance ETV Network--106 Stations

Cities	
1)	New York
2)	Los Angeles
3)	Chicago
4)	Philadelphia
5)	Boston
Interexchange channel miles	1,740
Networking cost	$14,350
Broadcasting cost	875
Total	$15,225
Cost per potential viewer	$ 0.16

Fig. 2--Five Largest City ETV Networks

provide nationwide free telephone access, the communications cost (phone line cost) for such a center (using estimates based on past experience in Madison, Wisconsin) would be about $587,000. This cost estimate is predicated on a utilization level of about 885,000 calls per year, which gives an average cost per call of sixty-five cents. Assuming the messages average six minutes in length, a physician could receive a sampling of consultations from ten leading specialists for a cost of only $6.50 per hour. Thus, the reduction of bandwidth reduces cost and makes this use of telecommunications feasible for consultative purposes.

Consider a third case. Imagine that one wishes to establish a single center to provide all the service currently provided through the informal system known as interlibrary loan. Such a center serving biomedicine would be responsible for providing copies of some one million documents every year.

The center might best perform this reproduction function by utilizing a general-purpose computer that will drive microfiche display devices coupled to hardcopy reproduction hardware. A system of this nature could easily be configured using available hardware.

The dissemination of the reproduced documents might take place in a variety of ways. We consider two alternatives: mailing of the pertinent documents to the user, and facsimile transmission using voice-grade lines. The cost of these services--for communications alone, and not considering any of the necessary terminal hardware--is considerably different. To mail the documents described would cost about $140,000 per year. Facsimile transmission, even at this high-utilization configuration, would cost on the order of $1,300,000 per year.

Mrs. Bridget Kenney, of the University of Mississippi, gave varying page charges observed in different situations using facsimile, accompanied by the caveat that prices could change drastically depending upon utilization. The price shown here seems about the minimum that can be gained through leased lines. Telephone transmission in this case would be an existing service, such as outward WATS. The service is operating in the range of ten cents per page, which is probably a lower bound. Even at this rate, the price of facsimile transmission is an order of magnitude greater than for transmission through the U.S. Mail. It is true that bandwidth compression by various means will eventually reduce this cost. Nevertheless, the mailing of documents is an extremely cost-effective way of transmitting information that is not critical with respect to time.

This point can be effectively crystallized by a rather "tongue-in-cheek" example used recently by J. L. Simonds:

> Let us consider a Boeing 707 jet freighter as a transmission channel. Assume that we wish to ship extensive library materials from New York City to Los Angeles. The cargo capacity of a 707 jet is 6,201 cubic feet. Let us load the plane with microfilm on

> which textual images have been recorded at a modest reduction ratio of 20:1. Assuming that each page of text contains 5000 alphanumeric characters, then, the plane would hold about 5.3×10^{13} bits of information. If we assume an hour for loading and unloading, and a cruising speed of 550 to 600 miles per hour, the data-transfer rate (bandwidth of a sort) would be about 2.5 gigabits per second (2.5×10^{9}) bits per second)!!
>
> For a TELPAK D channel to carry that much information would require about 20 months and would cost about $2,700,000. The cost of the 707 jet freighter by comparison would be about $10,000 and the total time of delivery would be about six hours.*

Certainly, no one will ever contemplate the exclusive use of one service or the other. But the message to the system designer is this: be sure you have a few 707s in addition to your TELPAKs. The library is an exceedingly complex operation, and in its ultimate conception will disseminate many different types of information: different with respect to criticality, density, volatility, volume, and many other factors. It seems senseless to search for a single technology that will be all things to all information transfer problems. Surely the answer lies in some mix of various communications modalities, ranging from six-cent postage stamps to communications satellites. The difficulty, of course, is in determining user needs and library capability in such a way as to define what combination of services best satisfies both the library and the customer.

The role of the library within various user communities is perceptibly changing. The problem addressed now is one of *information* transfer, as opposed to simply transmitting books, journals, or pages. Thus, it seems that emphasis in future systems might be expected to swing toward providing services that are outside the range of those traditionally

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*J. L. Simmons, *Information Technology for Network Operations*, Research Laboratories, Eastman Kodak Co., Rochester, N.Y., p. 7.

offered in a library atmosphere. A good number of these should be in the area of assisting the user's search for information, as opposed to being primarily concerned with the retrieval of information. The search process represents a considerably different discipline on the part of both the customer and the library, and will thus require technology considerably different from that which has been discussed. Most of what has been described represents *analog* storage. Effective support of search procedure will require a considerable emphasis upon digital storage of large data bases, accompanied by a methodology for providing close user interaction.

The prospects in the area of hardware are optimistic. Large scale digital storage, in the range of 10^9 bits and up, is already available through such techniques as laser recording. Other recently announced developments, such as eraseable holographic memories,* hold promise of extremely high capacities with relatively low space and power requirements.

Similarly, communications hardware developments continue at a rapid rate. Communications satellites and the prospect of a ubiquitous CATV system promise an abundance of broadband communications service at low per-capita costs.

Developments in communications and computer software have not kept pace. It is interesting to note that throughout this conference on Image Storage and Transmission Systems for Libraries no presentations have been devoted to software problems or systems, and the entire field has only been mentioned once. If information transfer is to occur, software must be available to provide the user the high degree of interaction that he needs to efficiently effect this transfer.

**Computerworld*, Aug. 20, 1969, p. 7.

Unfortunately, much of the software that will aid this process must deal with problems of "natural language," "pattern recognition," and "inference-making": problems usually subsumed under the heading *artificial intelligence*. The rather checkered history of this area is well known: it will suffice to say that breakthroughs here have been scarce and usually achieved at great cost.

Two causes may have contributed to this. Software in the areas described must be exceedingly complex, being required to operate upon highly ambiguous and indefinite inputs. Primarily, however, such software may have been unsuccessful because most attempts have been directed at solving the general problems of perception and analysis. What may be necessary is a turning away from this general approach, and a concentration upon specific problem areas. Such efforts must be preceded by determining the nature of the process one wishes to assist, and the preferred nature of this assistance:

1) Exactly how do professionals "search" through the library, index, or text;
2) What types of tools (both software and hardware) will best assist the professional in this search;
3) In the man-machine system, what are the most effective functions of the machine, and what areas are best left to the man?

Either answers to, or thorough investigations of these questions must be accomplished before effective software systems can be produced. Without such investigation, the prospects seem slim indeed.